CMS Data Products and Applications Overview

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Stakeholder feedback and engagement provides a link to science development, that helps a product move from a research effort...

Goals of CMS Applications Efforts:
- Link Stakeholders to CMS science products.
- Provide a path for feedback and lessons learned for CMS PIs so CMS is more accessible and user friendly.
- Inform NASA HQ of the needs and requirements of the carbon science community.
- Leverage opportunities between NASA CMS and stakeholders in an effort to expand the knowledge and familiarity of CMS data products to help improve decision processes.

...to a user friendly decision support system
CMS Applications Program Framework

**Policy Speaker Series**
Brings stakeholders to NASA to explain how carbon science data are applied to specific policies. Informs CMS science community of specific stakeholders data needs and collaboration opportunities.

**Applications Workshops**
Annual event with CMS Science Team and end users for a better understanding of stakeholder uses, needs and challenges for carbon monitoring and MRV as well as lessons learned.

**Data Products Fact Sheet**
Collection of CMS metadata and policy data for each product (e.g. spatial extent, resolution, uncertainty, application areas, relevant policies), Integrated into CMS website database.

**Application Readiness Levels (ARLs)**
Provide transparency to HQ and user community on the maturity of each CMS product. Used as a communication tool for stakeholders to assess product maturity.

**Surveys & Community Assessments**
Evaluate thematic user challenges within the CMS. Assess impact of CMS data products for end user organizations.

**Socioeconomic Studies**
Development of socioeconomic case study addressing the social value of CMS Lidar in MD DNR policy, and an ongoing assessment of the contribution of CMS flux products to the reduction of uncertainty in the carbon cycle.

**Feedback to CMS Science Community and NASA HQ ESD**
CMS Applications Efforts Examples. Tri-State Area Applications Workshop & Tutorial in Newtown Square, PA: CMS Application workshops and tutorials provide an opportunity for CMS Science Team members and stakeholders to engage on thematically detail objectives that help advance CMS science into appropriately scaled policy arenas.
ARL Refresher

- Serve as a guide to user community
- Set expectations to user on how to use products and what feedback to provide
- ARL designated by the CMS PI
- Update as needed
- Intended to guide HQ and user community on the maturity of products
CMS Stakeholder Survey for Science Team

- Main stakeholders: US EPA, USDA Forest Service, NOAA, CA ARB
- Not all stakeholders are using CMS data products at this moment
- All products, be research or operational products, have feedback potential
Stakeholders engaged by CMS Applications Efforts through Applications Workshops, Policy Speaker Series, and other engagement activities
The overarching objective of the applications effort is to broaden and strengthen the knowledge and engagement of the research and applications communities within the Carbon Monitoring System (CMS) Initiative.
Data Products & Applications Highlights
CMS Data Products

- **Aboveground biomass maps**
  - 30m Spatial Resolution
  - Status: Archived

- **Tree canopy cover map**
  - 1m Spatial Resolution
  - Status: Archived (some states) and In-Progress

- **Mangrove canopy height**
  - 1m Spatial Resolution
  - Status: Partially Archived

- **Maps of annual deforestation**
  - 30m Spatial Resolution
  - Status: In-Progress

- **Aboveground Biomass, Landcover, and Degradation for Kalimantan**
  - 1-ha grid cells
  - Spatial Resolution
  - Status: Archived

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Global forest canopy height (Healey, 2015)
Archived at ORNL DAAC

Available at: [https://doi.org/10.3334/ORNLDAAC/1271](https://doi.org/10.3334/ORNLDAAC/1271)
Overview of CMS Data Products

Where can CMS datasets be found?
PI: Sassan Saatchi, NASA JPL

**Description:** This data set provides maps of estimated carbon in forests of the 48 continental states of the US for the years 2005-2010.

**Spatial Coverage:** Conterminous USA (CONUS)

**Spatial Resolution:** 100-m resolution and county level

**Temporal Coverage:** 2005 - 2010

**Temporal Resolution:** Annual

**ARL:** 7

**Users & Purpose:** used extensively within the science community for reference purposes, and USFS has already used the data for validation of spatial variation of carbon for couple of states

**USFS Potential Applications:**
- A land manager at a regional level could use these data products to gain insight into changes in carbon in their regional forests
- Prioritization of forest management and land use policies
- Plan by the USFS to include this methodology for Mexico and other countries with limited or no national inventory approaches
- New IPCC guidelines about the use of RS data for carbon accounting

**Limitations & Future Work:** Limitations include reduced (a) spatial resolution of logging information (only at combined county-level) and (b) limited temporal resolution (5-year increment). Working to resolve limitations: moving to annual carbon mapping, and extending some of the products to Alaska.
**Lidar-Derived Aboveground Biomass and Uncertainty for California Forests, 2005-2014**

*PI: Jonathan Greenberg, University of Nevada, Reno*

**Description:** This dataset provides estimates of aboveground biomass and spatially explicit uncertainty from 53 airborne LiDAR surveys of locations throughout California between 2005 and 2014.

**Spatial Coverage:** Surveyed areas throughout California

**Spatial Resolution:** 30-m*

**Temporal Coverage:** 2005 - 2014

**Temporal Resolution:** Once

**ARL:** 4

**Users:** Carlos Ramirez from USDA Forest Service

Per-tree aboveground biomass (kg) derived from LiDAR-measured tree heights for the Blacksmith site in 2012 (from Blacksmith2012_389389N_12048484W.zip).

**USFS Potential Applications:**
- Aboveground biomass is an important metric for assessing carbon sequestration in forests.
CMS: LiDAR-derived Biomass, Canopy Height and Cover, Sonoma County, California, 2013
PI: Ralph Dubayah, University of Maryland

Description: This data set provides estimates of above-ground biomass (AGB), canopy height, and percent tree cover at 30-m spatial resolution for Sonoma County, California, USA, for the nominal year 2013.

Spatial Coverage: Sonoma County, CA, USA
Spatial Resolution: Grid cells at 30-meter resolution
Temporal Coverage: 2013
Temporal Resolution: One time
ARL: 9

Users & Purpose: The products have supported all facets of Sonoma County Agricultural Preservation and Open Space District’s work: field reconnaissance, conservation planning and prioritization, conservation easement design, easement monitoring and enforcement, and fee land management.

Feedback from Stakeholders – Successes:
- The data are being used widely, for applications in forest management, disaster response, education and outreach, scientific research, conservation, among others.
- Survey showed that 13 out of 59 respondents indicated that the data are mission critical or very important; and 33 indicated that they are important or nice to have.
- These data are being used to map priority areas for land conservation, and enable Ag + Open Space and their conservation partners to write competitive grant proposals and to demonstrate the value of habitat protection to our community and funders.
LiDAR-derived Biomass, Canopy Height and Cover for Tri-State (MD, PA, DE) Region, V2
PI: George Hurtt, University of Maryland

Description: This dataset provides 30-meter gridded estimates of aboveground biomass (AGB), forest canopy height, and canopy coverage for Maryland, Pennsylvania, and Delaware in 2011. ARL: 9

Spatial Coverage: Maryland, Pennsylvania, Delaware

Spatial Resolution: 30-meter or 90-meter


Temporal Resolution: Annual

<table>
<thead>
<tr>
<th>Users in Maryland</th>
<th>Purpose</th>
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<tbody>
<tr>
<td>Maryland Department of Natural Resources</td>
<td>- Using the CMS forest cover layer in their ecosystem service valuation work, and to develop the state forest carbon sequestration map. - Also looking into ways that CMS can inform the state’s forestry and sequestration sector, and help achieve the goals of the Greenhouse Gas Reduction Act.</td>
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<tr>
<td>Maryland Forest Service</td>
<td>- Habitat location analyses for Golden Wing Warbler. - Estimating the amount of stream buffer by county. - Various metrics for a multitude of smaller projects.</td>
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<td>Maryland Department of the Environment</td>
<td>- Modeling land cover in the Chesapeake Bay model.</td>
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<td>Baltimore City Department of Recreation &amp; Parks (TreeBaltimore Partnership)</td>
<td>- To monitor Urban Tree Canopy goals in the city.</td>
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<tr>
<td>The Nature Conservancy</td>
<td>- Map ‘natural’ forest, prioritize locations for forest inventory and inform restoration projects. - Looking at forest connectivity for climate resilience in the central Appalachian portion of western Maryland.</td>
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<tr>
<td>Queen Anne’s, Baltimore, Worcester, Caroline, and Talbot Counties</td>
<td>- For use in routine planning.</td>
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Aboveground biomass (Mg ha-1) at 30-m resolution for the tri-state region of Maryland, Pennsylvania, and Delaware in 2011.
National Scale Forest Disturbance Map
PI: Christopher Williams, Clark University

**Description:** 30-m resolution map with moderate to high intensity harvesting, bark beetle outbreaks, and wildfires, including year of disturbance, and for beetle outbreak and fire disturbances

**Spatial Coverage:** Conterminous USA (CONUS)

**Spatial Resolution:** 30-m resolution

**Temporal Coverage:** 1986 - 2010

**Temporal Resolution:** Annual

**ARL:** 7

**Users & Purpose:** TNC and the Climate Alliance have used / are using this dataset to assess opportunities for afforestation/reforestation as a natural climate solution pathway

**USFS Potential Applications:**
- To assess forest carbon uptake rates in diverse climate and forest type settings
- To assess the sustainability of timber resource management at state to regional levels
- To perform regional to national scale UNFCCC National Inventory Reporting
- To assess disturbance threats to US forests and impacts on the carbon balance of forested landscapes
- To assess the potential climate benefits of afforestation/reforestation
- To perform full forest sector carbon balance accounting

**Limitations:**
(1) attribution to disturbance type (harvest, fire, beetle outbreaks, wind, other) remains far from perfect – collaborators should be developing better alternatives;
(2) partial disturbance events are likely to be missing, including modest severity tree mortality events of scale smaller than 60 m x 60 m

Major Forest Disturbances Since the mid-1980s Mapped at 30-m Resolution. Williams et al. (2016) *Glob. Planet. Change*
Aboveground Biomass Maps for NW USA, 2000-2016
PI: Andrew Hudak, USDA Forest Service

Description: AGB wall-to-wall maps and lidar-based AGB maps for NW United States.

Spatial Coverage: Northwestern U.S. (WA, OR, ID)

Spatial Resolution: 30-m


Temporal Resolution: Annual

ARL: 5

Users & Purpose: Northwest Management, Colville Tribe in WA, USFS Idaho Panhandle National Forest in ID for forest level analysis/management

USFS Potential Applications:
- Wall-to-wall AGB maps would provide sufficient information for forest level analysis/management; Lidar-based AGB maps would be preferred for project level analysis
- Can help in the development of the Five-Year-Action-Plan (5-YAP) (e.g. USFS Region 4 & 6)
- Forest management for carbon sequestration

Lessons Learned: The needs and objectives of forest managers will remain local, centered on the lands they are charge to manage; because lidar is so informative for multiple natural resource management objectives, we can expect demand for lidar-derived products will continue, regardless of political priorities.
Highlighting Relevant CMS Tools for USFS

**Carbon Mapper**
PI: Riley Duren, NASA JPL
Description: a prototype data portal and analysis tool, which provides a common platform for visualizing information contained in selected CMS data sets.

**WFEIS Online Modeling Tool, PI: Nancy French**
Products for CMS were developed with the tool.

**AREA²**
developed by CMS PI Pontus Olofsson, BU
Discussion Questions

- What are your carbon data needs and interests?
- Are you using satellite or other remote sensing data for your work / decision-making?
- What other carbon science information (e.g. land cover change maps, methane flux estimates, coastal wetland carbon stocks and fluxes, etc.) do you need/want to support your agency/organization’s decision framework?
- What are the lessons learned you can share from using NASA CMS products, or similar products?
- Are there any improvements that can be made short term? Accessibility, time domain, spatial scale, and frequency of data updates?
- When and how should the carbon science information be delivered?
- What are some ongoing local initiatives in which NASA could contribute data and expertise?

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